

# Impact of Positive Emotions Enhancement on Physiological Processes and Psychological Functioning in Military Pilots

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## ABSTRACT

*“Despite of military’s captivation with high technologies systems, human performance remains the keystone of successful military operations” [1]. Cognitive enhancing-drugs strategies has been developed to improve the normal span of human abilities for completing mission essential tasks. A combination of certain attitudes and behaviours constituting a more natural approach based on physical training, sleep rest strategies, or dietary and nutritional strategies has also been proposed. Researches exploring the impact of emotions’ regulation on physiological processes and cognitive functioning are relatively scarce as studies has primarily focused on improving health and well-being by reducing negative emotions. The capacity to self-generate positive emotional states, however, can be developed and refined through the use of practical tools and techniques enhancing quickly shift to a physiologically quiet state by increasing parasympathetic flexibility, which is known to reflect an adaptive response to environment [2]. The French Army has developed a practical tool using different techniques in order to improve regulation of emotions before, during and after actions [3]. This psychological training is called “Technique d’Optimisation des Performances (TOP)”. The Institute of HeartMath® has also developed techniques for enhancing heart/brain synchronization (Heart Coherence; Cardiac Coherence (CC)), leading to a state of autonomic nervous system balance function that is correlated with improved cognitive function and health-related outcomes. The aim of this study is to evaluate the benefits of the use of these two practical tools for military pilots on conducting operational activities. Methods: Three groups of 10 middle-aged pilots were recruited from three different “escadrilles” to participate in the study. They were designed by the head-quarter for a 2-month mission in Afghanistan in the following months. A group's randomisation was made for determining a group for TOP training, a group for CC training, and a control group. Psychological training was performed during 6 to 8 weeks. The experimental procedure consisted in collecting (i) psychological data (resilience, well-being, anxiety), (ii) 12h-night urines to assess allostatic load (cortisol, adrenaline, noradrenaline, DHEAs, Dopamine excretions), (iii) 12h-night to assess heart rate variability and (iv) IgA measures. These data were collected once before the mission for the control group and twice before the mission for the TOP and CC groups (before and after the psychological training). These measures will be also collected at the end of the mission. Results: All results will be available at the end of the mission in July 2009.*

## 1.0 INTRODUCTION

The adaptative response to acute stress involves allostasis as the process of achieving homeostasis through physiological and behavioural changes faced to perceived and/or anticipated demand [4]. The main physiological response involves the Hypothalamo-Pituitary-Adrenal (HPA) axis which product cortisol, and the Autonomic Nervous System (ANS), which controls the release of adrenalin (epinephrine) from the sympathetic-adrenal-medullary system. The ANS constitutes an integrated system composed of two subsystems, the Parasympathetic Nervous System (PNS), which optimizes the function of the internal viscera by promoting anabolic activities and the Sympathetic Nervous System (SNS), which promotes increased metabolic output for intense muscular actions [2]. In response to a challenge, a transient

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## 14. ABSTRACT

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withdrawal of the parasympathetic tone occurs with a reciprocal increased sympathetic tone and an adrenalin secretion to quickly mobilize the existing reserves of the body. These changes promote fight-flight behaviours. Cortisol works more slowly to mobilize and replenish energy stores. It also increases arousal and vigilance, helps to focus attention with the risk of tunnel vision, and enhances encoding of emotion-related memory [5]. Cortisol inhibits its own activity through negative feedback acting in the pituitary, hypothalamus, and several extra-hypothalamic regions such as hippocampus and frontal cortex [6]. When stressor facing persists or when stress activation is inefficiently inhibited at the end of stressor facing, deleterious effects of stress reaction occur with negative consequences on psychological and/or cognitive abilities, featuring the allostatic load. The latter is underpinned by imbalances in PNS and excessive endocrine production. For instance, extensive evidences indicate that interactions between cortisol and noradrenaline facilitate emotional memory consolidation and may lead to post-traumatic stress disorder occurrence [6]. When challenge stops, the cortisol equilibrium is restored, and the parasympathetic tone increases to promote homeostasis recovery. The capacity of vagal tone to adapt to environmental changes defines the vagal flexibility. An appropriate vagal response involves therefore a high vagal flexibility that both allows sympathetic activity to occur and limits its activation to the period of stressors presence [7,2]. Consequently, healthy physiology could be features by high levels of adaptative variability. Referred to the importance of parasympathetic or vagal influences on cardiovascular regulation, the spectral analysis of heart rate variability (HRV) analysis is usually proposed as a method to assess vagal tone [7,2,8].

The mechanism by which perception may alter physiology, endocrine and immune functions and lead to pathology focus on the role of the limbic system in emotional experience, memory and learning. Whether the complex interplay between a number of brainstem nuclei and cell groups in the processing of information and the interpretation of experience, the role of amygdaloid complex is pivotal within the emotional system and may coordinate behavioural, immunological, and endocrine responses to environmental threats or perceived threats [4,9,10,11]. This complex is though to play a key role in comparing new incoming information with information stored in the emotional memory banks. Thus, by playing a pivotal role to determine the significant of the event [9], it makes instantaneous decision about the potential threat that incoming sensory information may pose [12]. Because of its extensive projections to the motor cortex, the lateral hypothalamus and other brainstem autonomic nuclei, this complex is able to “hijack” all other neural pathways to initiate behavioural response [13,14]. Each behavioural response leads to specific changes in immunity [15], cardiovascular system and stress hormones [9,16].

Because physical and psychological stresses are inevitable components of military life, studies in the military context are of considerable interest to researchers investigating normal and pathologic adaptation to stress. Over the years, stress responses and cognitive degradation to diverse military contexts have been documented using scenari designed to simulate realistic stressful contexts [17,18,19]. Although these studies can enhance stress sometime at intense levels, their simulation conditions may render them in fact unrealistic, limiting therefore their experimental interest for stress investigation. The relationship between these training scenarii to stressful military exercises carried out in the realiscity had not yet been investigated.

“Despite of military’s captivation with high technologies systems, human performance remains the keystone of successful military operations” [1]. Cognitive enhancing-drugs strategies have been developed to improve the normal span of human abilities for completing mission essential tasks. A combination of certain attitudes and behaviours constituting a more natural approach based on physical training, sleep rest strategies, or dietary and nutritional strategies has also been proposed. Most efforts to enhance cognition are of a rather mundane nature, and some have been practiced for thousands of years. The prime example is education and training, where the goal is often not only to impart specific skills or information, but also to improve general mental faculties such as concentration, memory, and critical thinking. Other forms of mental training, such as yoga, martial arts, meditation, and creativity courses are also in common use. Education and training, as well as the use of external information processing devices, may be labeled as “conventional” means of enhancing cognition. They are often well established and culturally accepted. Researches exploring the impact of emotions’ regulation on physiological processes and cognitive functioning are relatively scarce as studies has primarily focused on improving health and well-being by

reducing negative emotions. The capacity to self-generate positive emotional states, however, can be developed and refined through the use of practical tools and techniques enhancing quickly shift to a physiologically quiet state by increasing parasympathetic flexibility, which is known to reflect an adaptive response to environment [2].

The French Air Force has developed a practical tool using different easy techniques of mental skill in order to improve regulation of emotions before, during and after actions ten years ago [3]. This psychological training, called “Technique d’Optimisation des Performances (TOP)”, consists of several mental activities as respiration, relaxation, visualization (Users vividly imagine themselves performing a task, repeatedly imagining every movement and how it would feel), positive emotion recalls, which are adapt to be use for preparation, action, and recovery. General mental activity—“working the brain muscle”—can improve performance and long-term health, while relaxation techniques can help regulate the activation of the brain and sleep improvement [20,21,22]. The procedure of training is standardised for individual and group. The TOP are actually widely practiced in air traffic controllers, with apparently good effects. A likely explanation for the efficacy of such exercises is that they activate the neural networks involved in executing a skill at the same time as the performance criteria for the task is held in close attention, optimizing neural plasticity and appropriate neural reorganization.

The Institute of HeartMath® also has developed techniques for enhancing heart/brain synchronization (Heart Coherence, Cardiac Coherence (CC)), facilitating the maintenance of a physiologically efficient and highly regenerative inner state, characterized by reduced nervous system chaos and increased synchronization and harmony in system-wide dynamics. This psychophysiological mode, termed *physiological coherence*, is conducive to healing and rehabilitation, emotional stability, and optimal performance [23,24]. Recent research conducted at the Institute of HeartMath has demonstrated that HRV dynamics are particularly sensitive to changes in emotional state, and that positive and negative emotions can be readily distinguished by changes in heart rhythm patterns which are independent of heart rate. Specifically, during the experience of negative emotions such as anger, frustration, or anxiety, heart rhythms become more erratic or disordered, indicating less synchronization in the reciprocal action between the parasympathetic and sympathetic branches of the autonomic nervous system. In contrast, sustained positive emotions, such as appreciation, love, or compassion, are associated with a highly ordered or *coherent* pattern in the heart rhythms, reflecting greater synchronization between the two branches of the autonomic [25]. An important reason this technology is effective is that it uses HRV feedback for reflecting the activity of both the sympathetic and parasympathetic branches of the autonomic nervous system and the synchronization between them, and thus providing a window into the dynamics of the system as a whole. Compared to EEG feedback, HRV feedback is also considerably simpler and more straightforward to learn and use, which facilitates rapid improvement. Further, because the instrumentation utilizes only a simple pulse sensor requiring no electrode hook-up, it is extremely versatile and can be used easily and effectively as an educational tool not only in clinical settings but also in the home, in the workplace, in schools, or even while travelling. Its cost-effectiveness also makes it accessible to a greater number of people and in a wide range of applications. In relation to other biofeedback modalities, HRV feedback is also more reflective of changes in emotional/psychological state, and thus is particularly powerful in applications where reducing stress and increasing emotional stability are critical [23].

The aim of this study is to evaluate the benefits on stress of the use of these two practical tools for military pilots on conducting operational activities.

## 2.0 MATERIALS AND METHODS

### 2.1 Subjects

Three groups of 10 middle-aged men pilots from mirage 2000D (mean age 29.7 years, SD 3.9) were recruited from three different “escadrilles” stated at the 133 Air base (Nancy-Ochey, French) to participate in the study. They were designed by the head-quarter for a two-month mission in the Kandahar USA base (Afghanistan). They had served  $10.75 \pm 3.9$  years on active duty. Their educational background varied from

5 years (*i.e.*, pilot school) to 6 years (*i.e.*, more specialized technical courses). They had Afghanistan's experience (number of mission:  $2.8 \pm 2.08$ ). All volunteer individuals gave written informed consent before participation. The study was approved by the ethics committee of the French Military Health Service.

## **2.2 Operational and experimental procedures**

A group's randomisation was made for determining a group for TOP formation, a group for CC formation, and a control group. Psychological training was performed by an instructor for 6 for the CC group and 8 weeks for the TOP group with one hour with the instructor per week. They were required to have individual training between each formation-time. The instructor was present at the base of Kandahar one month at the end of the mission in order to maintain the practice.

The assessments consisted in collecting (i) psychological data with psychological-trait and psychological-state measures, (ii) 12h-night urines to assess allostatic load (cortisol, adrenaline, noradrenaline, DHEAs, Dopamine excretions), (iii) 12h-night to assess heart rate variability and sleep activity (iv) salivary IgA. These data were collected once before the mission for the control group and twice before the mission for the TOP and CC groups (before and after the psychological training). These measures will be also collected at the end of the mission. For the Reference group, the procedure consisted in psychological questionnaires, biological and physiological assessments at two time-points: before (Baseline) at the 133 AB and immediately after the mission (After Mission). For the TOP and CC groups, the procedure consisted in psychological questionnaires, biological and physiological assessments at three time-points: before (Baseline), immediately after the TOP or CC formation (Post Formation, PF), and immediately after the mission (Post Mission, PM). For all subjects, the assessments were exercise was carried out between 15h30 and 18h00 in order to control circadian variation.

## **2.3 Psychological measures: self-administered questionnaires**

### **2.3.1 Psychological-trait measures**

The Levenston's locus of control scale constitutes a standard self-report instrument for personality in terms of control locus [26,27,28]. It is a 24-item self report questionnaire for studying three factors corresponding to the three locus of control: Internal, Powerful others and Chances (IPC). Analysis of relationships between locus of control and personality inventory that measures the "big five" showed: (i) I negatively correlates with Neuroticism and positively with Extraversion and Conscientiousness, (ii) P positively correlates with Neuroticism and positively with Openness and Agreeability, and (iii) C positively correlates with Neuroticism.

The Toronto Alexithymia Scale-20 (TAS) is a 20-item self report questionnaire developed from the 26-item self-report scale [29]. It is considered as the standard self-report instrument for studying the three factors corresponding to three of the four theoretical dimensions of the alexithymia construct. The first dimension reflects the ability to identify and describe feelings and to distinguish between feelings and bodily sensations. The second dimension reflects the ability to communicate feelings to other people and the third dimension, the externally oriented thinking. The daydreaming factor is not assessed in the 20-item form. The total score and the score of three subscales were computed.

The Coping Inventory Stress Situation is a 48-item self report measure that assesses three general coping styles: task-oriented coping, emotion-oriented coping and avoidance-oriented coping [30]. Separate factor analyses of avoidance coping items have yielded support for two components of avoidance-oriented coping: distraction and social diversion. Coping refers to the set of cognitive and behavioural strategies used by an individual to manage the demands of stressful situations [31]. Specially, task-oriented coping is considered to promote effective recovery from many types of stressful situations [32].

The Dispositional Resilience Scale-Revised is 15-item self report questionnaire [33]. It measures three related dimensions of resilience: commitment, control, and challenge.

The Spielberger State-Trait-Anxiety Form Y Inventory: The Spielberger State-Trait-Anxiety Inventory (S-STAI) is a 40-item self report questionnaire [34]. In the trait scale, the 20 items ask respondents to indicate the intensity of their anxiety in general.



The Freiburg Mindfulness Inventory (FMI) used in this study is a short form with 14 items developed for common contexts, where knowledge of the Buddhist background of mindfulness cannot be expected [35,36]. This scale derives from the original FMI which is a thirty-item self-administered questionnaire directly developed qualitatively out of the original Buddhist concept of mindfulness. It constitutes a consistent and reliable scale evaluating several important aspects of mindfulness, which probably is one-dimensional [36]. Each self-descriptive statement was evaluated using a four-point Likert scale ranging from 1 (strongly disagree) to 4 (strongly agree). Depending on the suggested time-frame, state- and trait-like component could be assessed. In the present study, the short form was used for measuring the mindfulness-trait.

### 2.3.2 Psychological-state measures

The Perceived Stress Scale (PSS; 37,38) is a 14-item scale designed to assess subjects' appraisal of how stressful their life situation feels to them. The PSS is recommended for assessing non-specific appraisal because it is found to better predict stress-related psychological symptoms and physical symptoms compared to commonly used life event scales [39,40].

The general Self-Efficacy Scale (SES) consists in a 17-item self report measure that asks the subjects to rate their confidence in their ability to be consistently successful in organising and implementing the courses of action required to produce given attainments [41]. One measure of general self-efficacy was obtained being specifically designed for managers [42]. General self-efficacy is found to be an important aspect of functioning in a variety of realms [41]. The beneficial effects of self-efficacy include coping with trauma [43] and performance [41].

The Positive and Negative Affect Schedule consists of two scales that assess positive (PA) and negative affect (NA), respectively (PANAS, 44). Each scale has ten word emotion descriptors and respondents rate how well each descriptor reflects their current emotions. Each word is ranged on a scale from one to five, as to whether the word fits the usual or time-limited state of the individual. In this study, the general, or usual state, was requested.

The mood was evaluated using an abbreviated version (45; 5 min) of the Profile of Mood States (POMS). It consisted in an adjective checklist of 37 items rated on a five-point scale that ranges from (1) "not at all" to (5) "extremely". The subjects were asked to answer according to their present mood. Six factors were then calculated: anxiety-tension, vigor-activity, depression-dejection, anger-hostility, fatigue-inertia, and confusion-bewilderment.

The Warwick-Edinburgh Mental Well-Being scale (WEMWBS, 46) is a measure of mental well-being focusing entirely on positive aspects of mental health. It consists in 14 items covering both hedonic and eudaimonic aspects of mental health including positive affect, satisfying interpersonal relationship and positive functional.

The Cungi stress and stressors scale consists of two scales that separately assess perceived stress (Cungi stress) and perceived stressors (Cungi stressors; not published). The stress scale has eight items evaluating the level of stress perceived by the subjects. The stressors scale has eleven items evaluating the perceived level of physical, mental and environmental for subjects.

The Combat Platoon Cohesion Questionnaire (CPCQ) short version derived from the CPCQ developed by G Siebold in 1988 [47,48,49]. The original instrument is based on a conceptualization of cohesion as three types of bonding: horizontal (bonding among peers), vertical (bonding between leaders and subordinates), and organizational bonding. It consists of 79 base items used to form 3 horizontal bonding scales, 2 vertical bonding scales, and 6 organizational bonding scales. The current version of the CPCQ appeared to be a solid, serviceable, in-depth measure of cohesion at the platoon level. For the short version, the one or two best questions from each scale were selected and revised if necessary to form a twenty question instrument focusing exclusively on cohesion and with a five-point response scale for each item. Analyses conducted to investigate the internal properties of the short questionnaire and its cross-correlation with the longer CPCQ instrument and various criteria indicated that the cohesion scales from the short questionnaire constitutes a consistent and reliable scale. In the present study, the short form was only used with the horizontal, vertical bonding.

## **2.4 Physiological assessment: cardiac vagal tone**

The cardiac vagal tone was evaluated from the electrocardiogram (ECG). The ECG was recorded using a portable recorder (Temec instrument, Vitaport CPS) in each experimental step. It was digitalized with a 1000-Hz sampling rate to accurately detect R-wave peaks. The ECG trace and the detection marks were displayed together to be checked. All the ECG data were free from arrhythmia and artifact, except five cases of singular premature heart beats. The time series of interbeat intervals were generated and the spectral analysis of Heart Rate Variability (HRV) was then carried out using the Fast Fourier Transform algorithm [50]. The HRV spectral analysis focused on low- (LF, <0.1 Hz) and high-frequency (HF, >0.15 Hz) bands. The LF rhythm contains both sympathetic and parasympathetic contributions, whereas the HF rhythm primarily reflects vagal efferent tonus. According to published recommendations [51], HRV was quantified by LF/HF, assumed to reflect the cardiac sympathovagal balance.

## **2.5 Available biological assessments**

Salivary cortisol, a reliable marker used for HPA axis activity [52], was sampled at the Baseline, Escape and Recovery steps leading to 39 samples from the 13 subjects. Each 5 mL saliva sample was collected in Salivette tubes according to specification of the provider (Sarstedt; Inc., Newton, NC). Two hours before each collection, eating, drinking or smoking were not allowed. Once filled, the tubes were centrifuged, sampled into 1.5 mL aliquots stored at -80°C until analysis.

The nocturnal urinary free cortisol excretion was assessed as marker of anticipatory anxiety. The subjects were instructed to collect urines from 18h00 to 6h00. Once retrieved, urine volume was measured and a 2-mL sample was taken then stored at -80°C until analysis.

Cortisol concentrations were measured using radioimmunoassay kits according to the protein concentration rates (Siemens Healthcare Diagnostics, Germany). The urinary cortisol excretion rates were calculated according to the diuresis and the creatinine excretion rates.

The other urinary biological markers as salivary IgA level were not available at this date.

## **2.6 Data analysis and statistical methods**

The statistical analysis was performed using SPSS 11.0 software package (SPSS Inc., Chicago, IL, USA). Comparisons between groups at Baseline were carried out using independent *t* tests. Effects of the psychological training on physiological, endocrine and psychological data were assessed using paired *t* tests between Baseline and Post Formation separately for the TOP and the CC groups. Comparisons between the Reference group at Baseline, the TOP group at PF and the CC group at PF were also carried out using independent *t* tests. Comparisons between groups at Post Mission were carried out using independent *t* tests. Relationships among physiological, endocrine, and psychological responses were studied using Pearson's correlation test at Baseline, PF and PM separately. Statistical significance was set at  $p < 0.05$  but trends ( $p < 0.10$ ) were also reported due to the small population in each group. Results were expressed as mean and standard deviation.

# **3.0 RESULTS**

## **3.1 Comparisons between groups at Baseline**

Psychological trait assessments for pilots at Baseline were given in table 1, and compared to standards when it is possible.



Test	Factors	Standard	Pilots				
			Total N=30	Ref N=10	CC N=10	Top N=10	t-tests
IPC	Internal	31.3 ±6.2	33.81 ±5.07	36.37 ±3.96	34.33 ±4.56	31.58 ±5.58	TOP<Ref**
	Powerful others	14.4 ±6.6	14.87 ±6.53	12.62 ±7.01	13.33 ±5.79	17.92 ±6.24	TOP>CC* TOP>Ref*
	Chances	16.6 ±5.8	17.44 ±5.15	16.25 ±5.23	16.58 ±5.23	19.08 ±4.96	
TAT	Ability to identify and describe feelings	14.51 ±5.22	10.28 ±3.32	9.5 ±3.25	11.25 ±2.89	9.07 ±4.54	
	ability to communicate feelings	13.16 ±4.1	10.87 ±2.09	10.62 ±1.41	11 ±1.54	10.07 ±4.13	
	externally oriented thinking	19.62 ±4.67	19.75 ±1.56	19.87 ±2.03	19.75 ±1.76	18.15 ±5.55	
CISS	Task-oriented coping	61 ±10.29	57.19 ±7.37	60.75 ±5.34	55.08 ±7.72	52.54 ±17.46	CC<Ref*
	Emotion-oriented coping	41.85 ±10.55	37.29 ±10.08	32.62 ±11.61	38.25 ±10.3	39.64 ±8.3	
	Distraction	37.22 ±11.14	36.26 ±8.92	36.5 ±12.77	38.09 ±5.8	31.76 ±12.66	
	Social diversion	14.25 ±5.2	12.78 ±3.98	12.37 ±4.98	12.91 ±4.25	12.92 ±3.26	
	Diversion	15.56 ±5.23	16.56 ±5.28	17.12 ±7.28	17.16 ±2.98	14.38 ±7.09	
DRS-R	Commitment		11.84 ±1.87	13.12 ±1.25	11.16 ±2.03	11.66 ±1.72	CC<Ref** TOP<Ref**
	Control		11.06 ±2.30	11.25 ±2.76	11.33 ±2.31	9.85 ±3.58	
	Challenge		9.97 ±2.57	11.37 ±1.99	9 ±2.66	9.23 ±3.7	CC<Ref**
T-STAI	Trait		35.53 ±9.47	29.37 ±4.63	37.08 ±10.12	38.08 ±9.98	CC>Ref** TOP>Ref**
FMI		37,24 ±5,64	39,38 ±5,76	41,25 ±3,57	37,58 ±5,68	39,33 ±8,05	CC<Ref*

**Table 1: Mean ±standard deviations for the psychological trait assessments for standards, pilots population, Ref group, CC group, and TOP group at Baseline. IPC: Internal, Powerful others, and Chance locus of control, TAT Toronto Alexithymia test, CISS: Coping Inventory for Stressful Situation, DRS-R: Dispositional Resilience Scale-Revised, T-STAI: trait-Spielberger Anxiety Inventory, FMI: Freiburg Mindfulness Inventory**

Results showed significant differences between groups for the Levenston's locus of control (IPC), the task-oriented coping, the anxiety, FMI scores. Compared to the TOP and CC groups, the Reference group is prone to higher internal locus of control, task-oriented coping, commitment, challenge, mindfulness levels and lower trait-anxiety level.

For psychological state assessments at Baseline, results showed significant differences between groups for the PANAS, PSS, WB, cohesion and the POMS scale (Figure 1). Compared to the TOP and CC groups, the Reference group is prone to higher positive affects, well-being, vertical cohesion, activity-vigor and lower negative affects, perceived Stress, tension-anxiety.

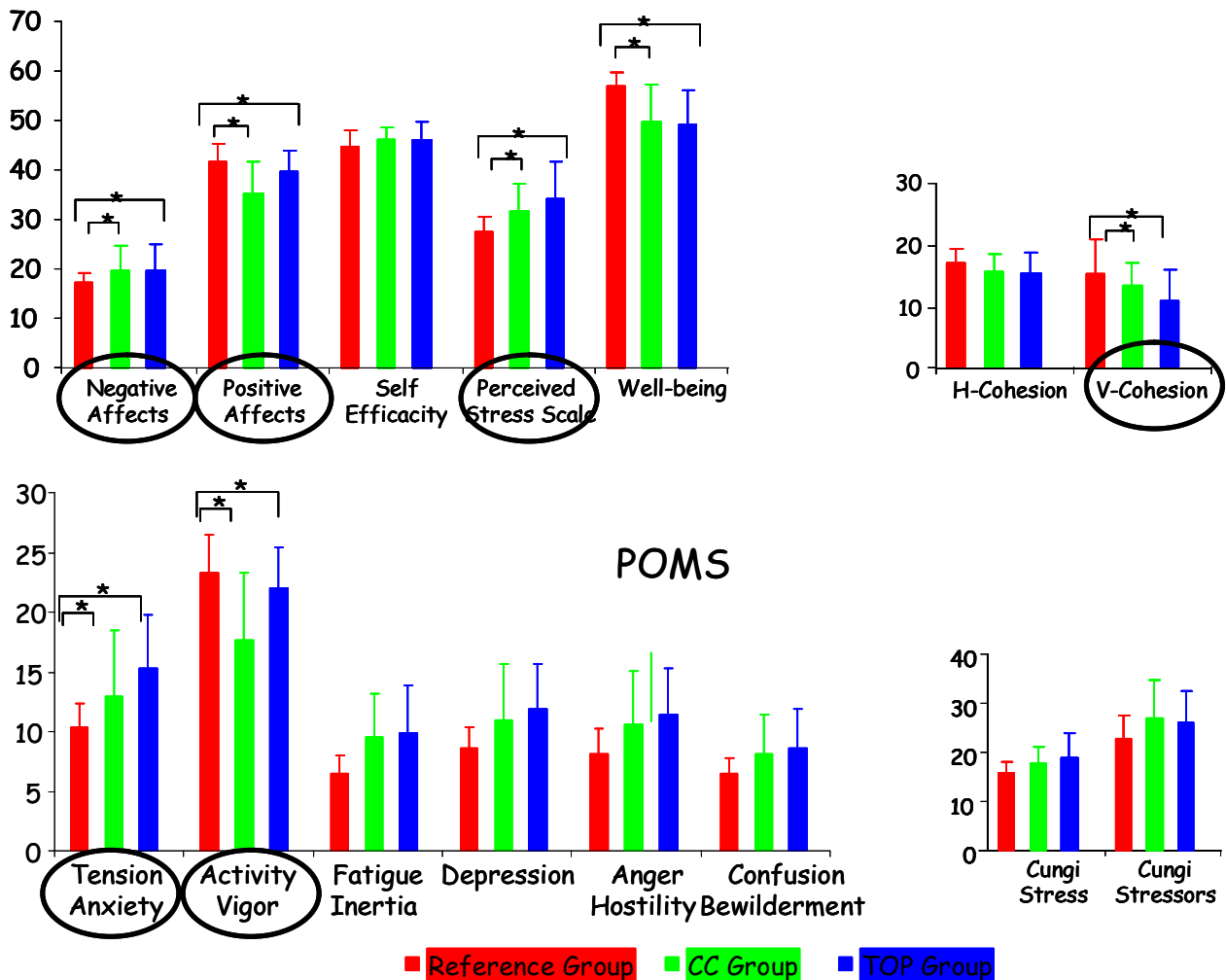


Figure 1: Means  $\pm$  standards deviations for the psychological state assessments for the Ref group, CC group, and TOP group at Baseline. H-cohesion: Horizontal cohesion, V-cohesion: vertical cohesion.

For the sympatho-vagal balance data (Table 2), the Reference group and TOP group exhibited a higher LF/HF index than the CC group. No difference was observed between the Reference group and the TOP groups. No difference was observed between groups for urinary cortisol level (Table 2). Whatever the group, no correlation was observed between LF/HF index and urinary cortisol concentration.

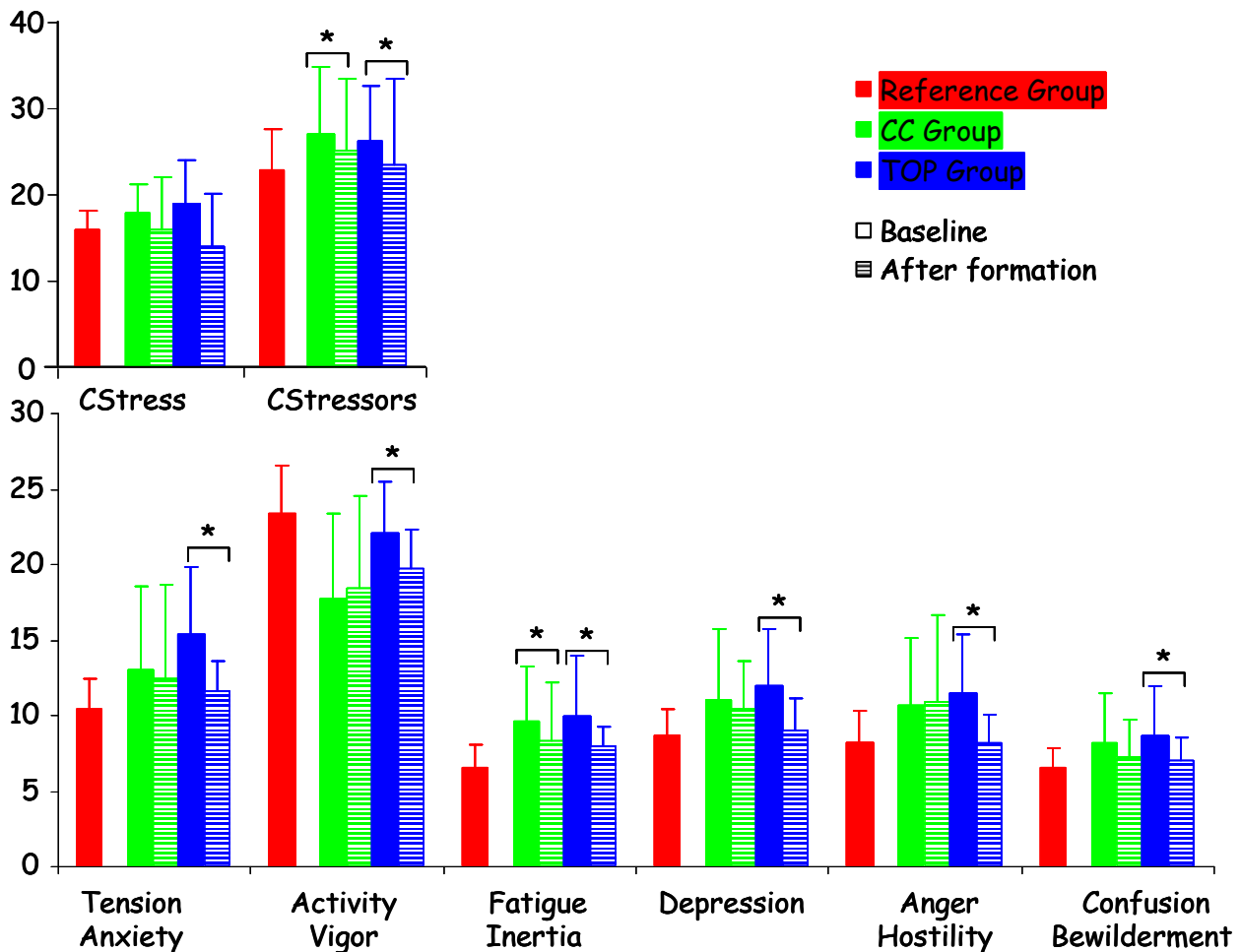
	Reference	CC	TOP	
LF/HF	4.07 $\pm$ 3.72	1.70 $\pm$ 0.48	4.48 $\pm$ 3.72	CC<TOP* CC<REF*
Urinary cortisol	118.94 $\pm$ 41.73	121.89 $\pm$ 50.52	154.24 $\pm$ 69.63	

Table 2: Mean  $\pm$  standard deviations for the LF/HF ratio and urinary cortisol concentration for the Ref group, CC group, and TOP group at Baseline. \* indicates  $p < .05$ .

### 3.2 Effects of the psychological training on the assessments

Whether TOP and CC formations induced some changes on assessments, effects depended on the psychological training.

For the psychological state, results were given in Figure 2.



**Figure 2: Means  $\pm$  standard deviations for the psychological state assessments for the Ref group, CC group, and TOP group at Baseline and After formation. CStress: cunгы Perceived Stress, CStressors: Cунгы perceived Stressors. \* indicates  $p < .05$ .**

The CC formation decreased the scores for the Cунгы perceived stressors and fatigue-Inertia scales ( $p < .05$ ). The TOP formation decreased the scores for the Cунгы perceived stressors, tension-anxiety, fatigue-inertia and depression, anger-hostility and confusion scales and increased the score in the activity-vigor scale.

For the sympatho-vagal balance (Table 3), no significant change was observed after formation for the CC group whereas a significant decreased of LF/HF was observed for the TOP group.

For biological assessments (Table 3), no significant change was observed after formation for the CC group whereas a significant decreased of urinary cortisol concentration was observed for the TOP group.

	Groups	Baseline	After formation
LF/HF	CC	1.70 ±0.48	2.38 ±1.84
	TOP	4.48 ±3.72	2.59 ±3.16*
Urinary cortisol	CC	121.89 ±50.52	114.76 ±49.38
	TOP	154.24 ±69.63	96.31 ±47.68**

**Table 3: Mean ±standard deviations for the LF/HF ratio and urinary cortisol concentration for the CC group, and TOP group at Baseline and at After formation. \* indicates  $p < .05$ , \*\* indicates  $p > .01$ .**

After formation, the comparison between the CC and the TOP groups showed differences between the two groups for the PANAS (higher PA score for the CC group), for the PSS (higher score for the CC group), for the WB scale (higher score for the CC group). Results failed to differ for LF/HF as for urinary cortisol concentration (Figure 2,  $p > 0.05$ ).

When comparing the CC group after formation to the reference group at Baseline, the psychological state differences disappeared. When comparing the TOP group after formation to the reference group at Baseline, the TOP group exhibited lower well-being, activity-vigor, positive affects and higher negative affects, Perceived Stress, tension-anxiety and fatigue-inertia ( $p < .05$ ).

Compared to the reference group at Baseline, the CC group After Formation exhibited a lower LF/HF value but no difference for the urinary cortisol concentration and the TOP group After Formation exhibited a lower urinary cortisol concentration but no difference for the LF/HF value ( $p < .05$ ).

### **3.3 Effects of the psychological training on the After Mission assessments**

As the TOP group will go back to France in October 2009, analysis only compared the CC and the reference groups. For the two months at Kandahar, the mission daily book showed no difference between the CC and the Reference groups whatever the number, the type and the risk of the fly mission. Moreover, no difference was observed for the “quality of life, day and night” at the Kandahar base.

When regarding the effect of the mission for the CC group, significant differences for psychological assessments were observed between the After formation (before the mission) and the After mission time points. After the mission, subjects exhibited a lower PSS score, a higher WB score, and a higher activity-vigor score ( $p < .05$ ). Moreover, vertical cohesion increased ( $p = .07$ ).

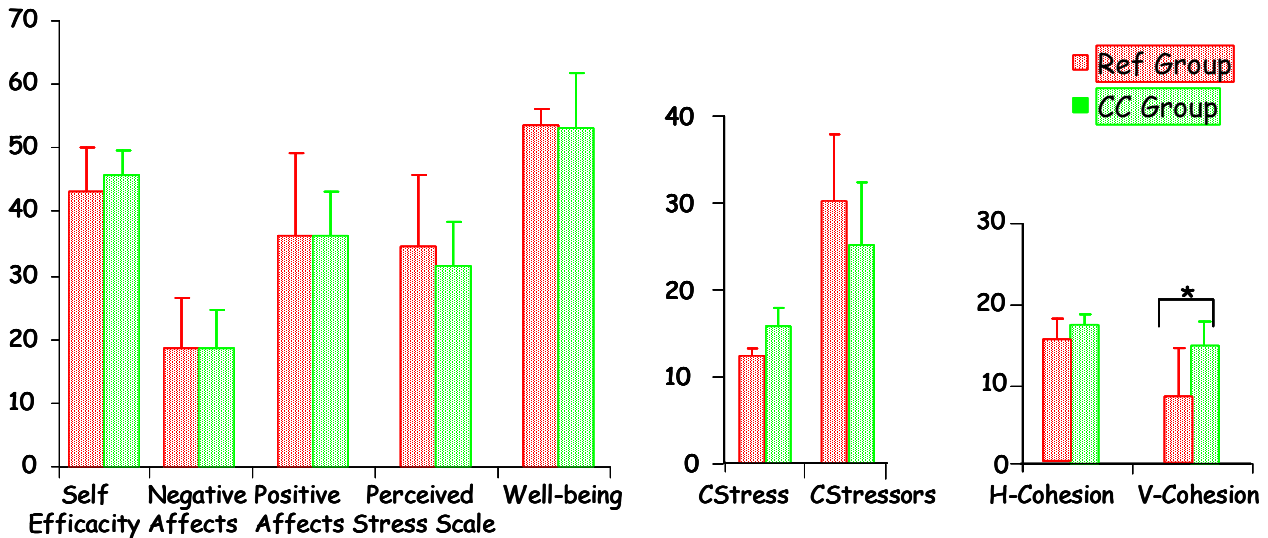
For the sympatho-vagal balance (Table 4), no significant difference was observed between the two time points. For the urinary cortisol concentration (Table 4), no statistical difference was observed although the urinary cortisol concentration was higher at After formation compared to After mission ( $p = .1$ ).

	Groups	After mission
LF/HF	CC	2.93 ±0.59
	Ref	4.53 ±2.09
Urinary cortisol	CC	79.25 ±39.13
	Ref	99.1 ±58.5

**Table 4: Mean ±standard deviations for the LF/HF ratio and urinary cortisol concentration for the ref group and the CC group at After mission.**

When regarding the effect of the mission for the Reference group, no significant differences for psychological assessments were observed between the before mission (Baseline) and the After mission time points although subjects exhibited higher fatigue ( $p = .1$ ), lower self efficacy ( $p = .09$ ) and lower vertical cohesion ( $p = .1$ ) after the mission. For the sympatho-vagal balance as for the urinary cortisol concentration (Table 4), no significant difference was observed between the two time points.

When comparing the two groups at the After mission time point, results failed to show significant difference, except for the vertical cohesion score with a higher vertical cohesion for the CC group compared to the reference group (Figure 3).



**Figure 4: Means ± standard deviations for the psychological state assessments for the Ref group, CC group, and TOP group at Baseline and After formation. CStress: Cungy Perceived Stress, CStressors: Cungy perceived Stressors, H-cohesion: Horizontal cohesion, V-cohesion: vertical cohesion. \* indicates  $p < .05$ .**

For the sympatho-vagal balance as for the urinary cortisol concentration (Table 4), no significant difference was observed between the two groups.

## 4.0 DISCUSSION

This study evaluated the psychological, the physiological (sympathovagal balance, LF/HF ratio) and biological (12 night-cortisol concentration) changes induced by the practice of two different intervention programs among French pilots conducting an operational 2 months-mission in Afghanistan.

Although the groups were randomized, psychological, physiological and biological differences were observed between the three groups. The reference group exhibited higher positive psychological index of resilience (27,31,36 53; internal locus of control, task-oriented coping, commitment, challenge, mindfulness trait-anxiety) associated with some lower negative psychological states (negative affects, Perceived Stress, tension-anxiety) and higher positive psychological states (positive affects, well-being, vertical cohesion, activity-vigor). Moreover, differences were also observed for the sympatho-vagal balance (higher LF/HF index for the Reference and TOP groups). Such results conflict with the necessity to balance confounding factors between treatment groups for clinical trial. One explanation was the groups' randomisation instead of subjects' randomization due to operational reasons.

Whatever the intervention program, the practice induced reductions in stress levels and in some negative affects scales which was combined with a significant increase of the activity-vigor in the TOP group. When comparing the two practices, the TOP formation appears to induce more changes in the POMS factors scale than the CC formation. Moreover, in addition to a decrease of the urinary cortisol level, the TOP formation induced a shift of sympathovagal balance towards parasympathetic dominance (decreased LF/HF ratio).

When comparing the groups after formation to the reference group at Baseline, no difference was observed on psychological scales for the CC group and the TOP group exhibited higher positive psychological states and lower negative psychological states for several scales. Moreover, compared to the reference group at Baseline, the practices sustained a lower LF/HF value for the CC group and induced a lower urinary cortisol concentration for the TOP group.

In accordance with the observed changes, these two formations are specifically designed to modify the automatic negative emotional responses that occur, due to the emotional programming in our brainstem nuclei, by changing the afferent sensory input to these nuclei [9,16] and to enable people to “lock in” to sustained positive states in order to boost their energy, heighten peace and clarity and regulate neuroendocrine and sympathovagal balances [24,25].

When regarding the effects of CC practice to cope with the two-month mission in Kandahar, benefit appeared with an increase for some positive psychological states combined with a decrease for some negative psychological states. In addition, a tendency to a decrease for the urinary cortisol concentrations at the After mission time point was observed. Such cortisol pattern was observed for the reference group but failed to be significant. This endocrine pattern suggests that the mission constitutes a stressor. It could be highly evocative for an anticipation of threat which disappeared at the end of the mission [52]. The CC program could be efficiently for decreasing the allostatic load induced by the mission [4,6]. Such benefit appears all the more important than missions will become longer and more frequent.

In addition, an increase of the assessed vertical cohesion was observed for the CC group whereas impairment occurred for the Reference group. The model group cohesion is based on social integration in the military and is composed of both primary (peer and leader bonding) and secondary group cohesion (organizational and institutional bonding). The essence of peer bonding (horizontal cohesion) is given as social relationships based on trust and teamwork. The essence of leader bonding (vertical cohesion) refers to the shared commitment among members to achieving a goal that requires the collective efforts of the group. A group with high leader bonding appears prone to have high task cohesion as members share a common goal and are motivated to coordinate their efforts as a team to achieve that goal. Task cohesion is considered to be important in enhancing group performance [48,49]. Unfortunately, data on the relationship between performance level and the CC intervention program was not recorded. However, such results suggest that the CC program practiced in the Kandahar base helped the group to cope with the required tasks and could protect it against bad vertical relationship. The role of the presence of the instructor with the CC group during half of the mission could be involved in the improvement observed in the vertical cohesion scale.

Whether beneficial changes due to CC and/or TOP intervention programs were observed, results must be interpreted with caution because of the smaller size of the groups, of the highly selected sample of subjects and also because assessments were collected once for one day at each time-point. Moreover, the protocol was not a double-blind, placebo-controlled clinical trial. Pilots known what they're getting, their belief about what will happen could taint the results. Because the researchers known either, they can hint to patients about what they're getting, and they also could taint results through their own biased expectations about what the results will be. Further evaluation with a pharmacologic (e.g., a tablet), or psychological (e.g., a conversation) placebo is necessary. Whether the practice of these intervention programs enhances performances and promotes right decisions and ethical behaviours when conducting operational missions needs further investigations.

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